Cellulose nanofibers- Graphene Oxide Hybrid Membranes for Water Purification

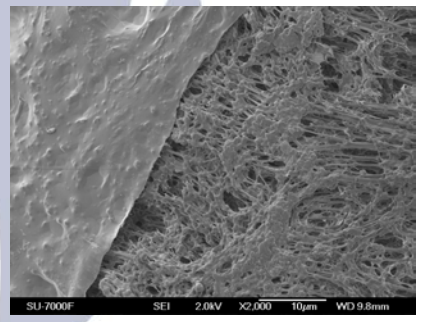
Aji P Mathew, Peng Liu, Chuantao Zhu

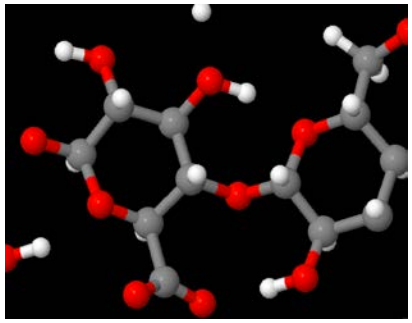
Department of Materials and Environmental Chemistry,

Stockholm University, Sweden

24 July 2018, ISBBB, Guelph

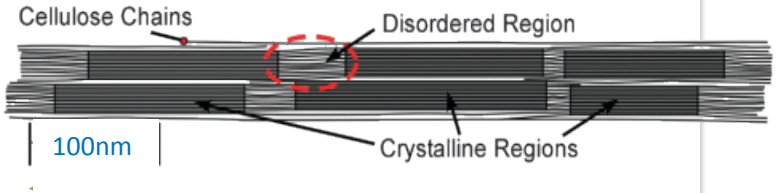




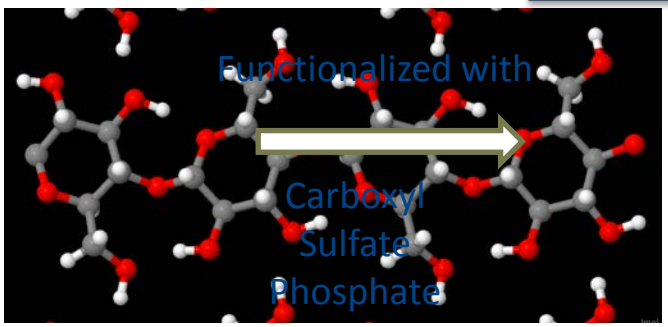
Nanocellulose Membranes: Perspectives

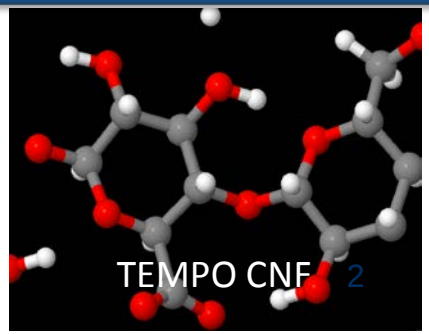
- Abundant, sustainable, biodegradable , non-toxic
- Excellent mechanical property
- **High specific surface area**
- **Functionlizable surface**
- **Hydrophilicity (antifouling)**
- **Abundance of adsorption sites**
  - ***Short intra-particle diffusion distance and fast kinetics***
  - ***Efficient adsorption at low concentrations (ppm to ppb level)***
- **Networking properties of CNF**



Microfibril structure (CNF&CNC)

Charged Membranes !!!





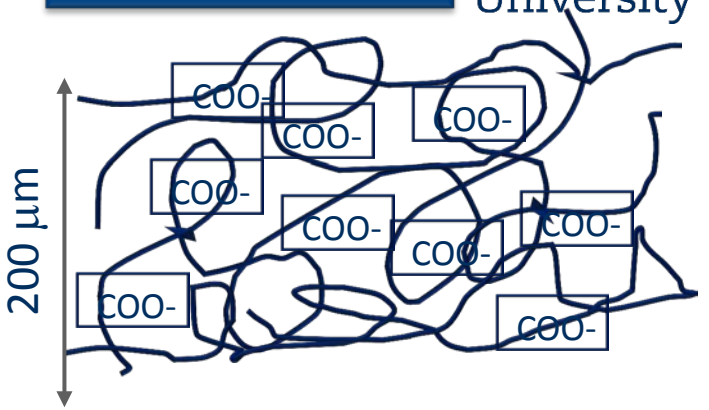
R. J. Moon et al, Chem. Soc. Rev., 2011; H. V. Lee et al, Scientific World J., 2014

Nanocellulose Membranes: Perspectives

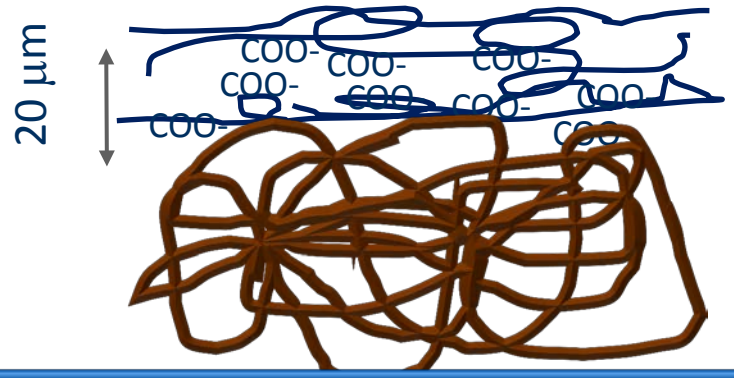
Stockholm University

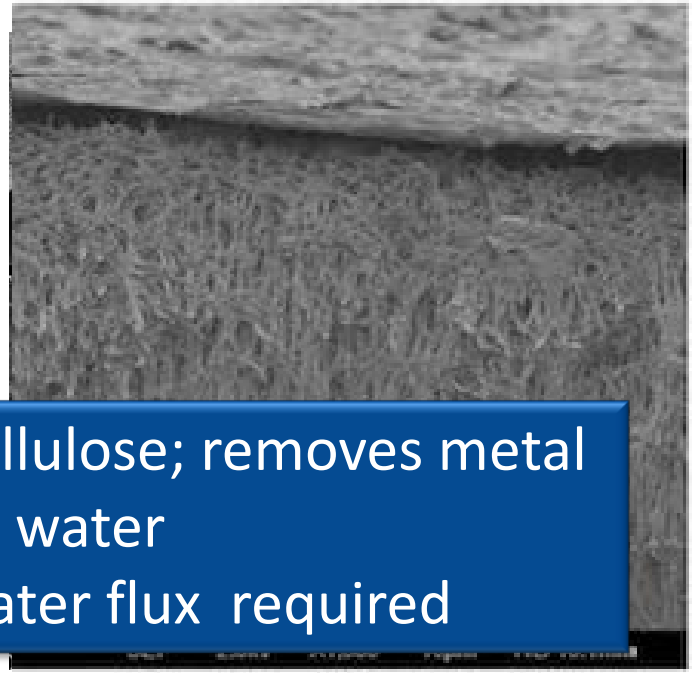
- Charged affinity membranes
  - *Adsorbs pollutants with opposite charge; rejects same charge*
- Rejects by size exclusion (pore structure dependent)

Isotropic



Anisotropic



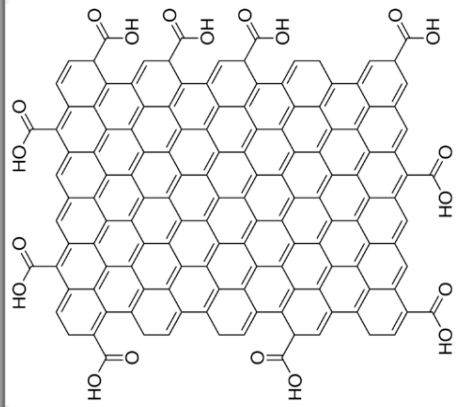


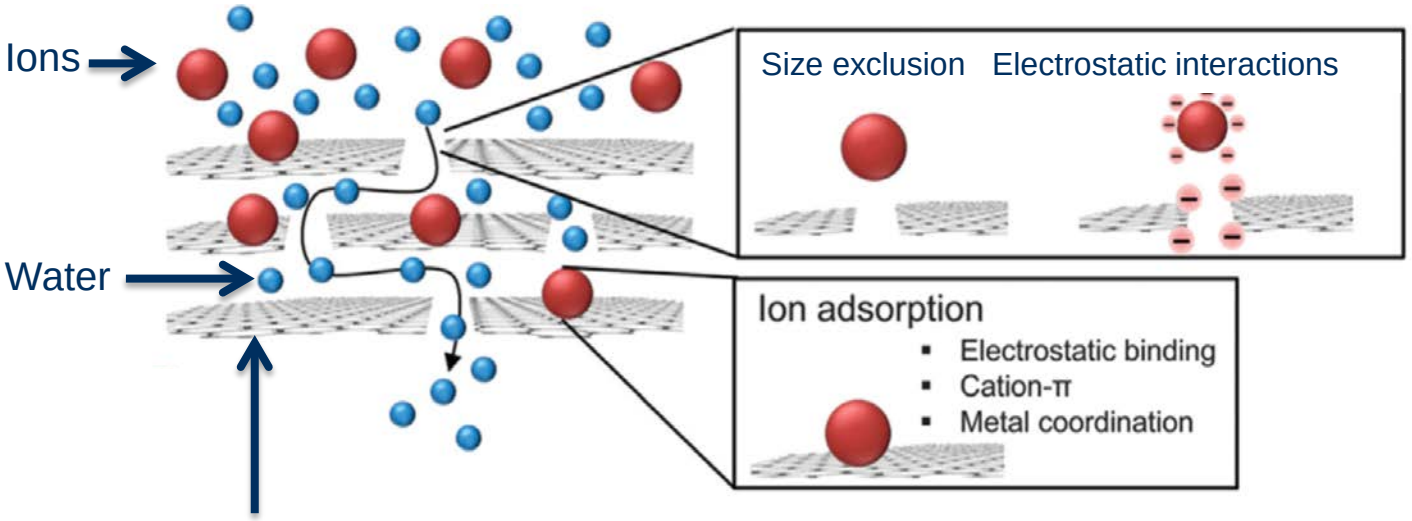
- Very promising application for nanocellulose; removes metal ions, dyes, fertililzers, pesticides from water
- Improvement in water stability and water flux required

Objectives

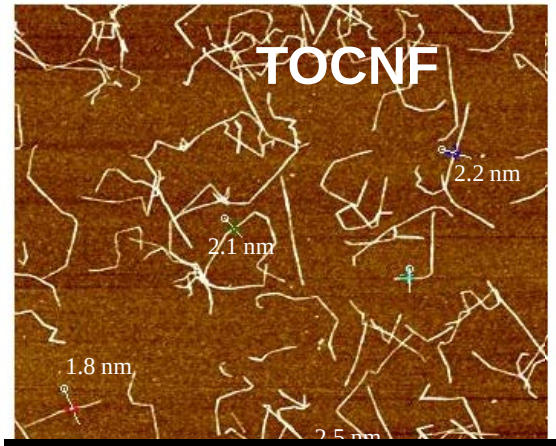
Graphene oxide (GO)

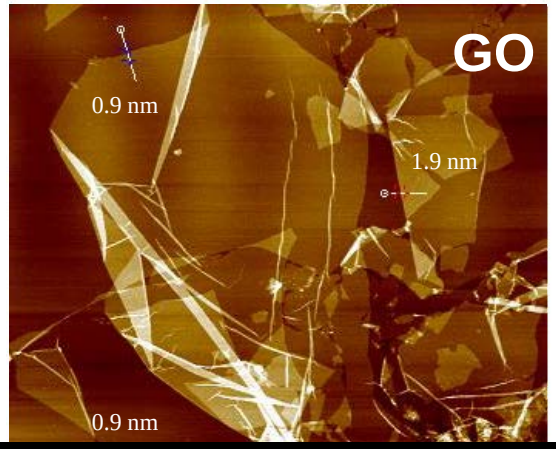
- **Morphology:** 1D structure with 1nm thickness, Formation of nanocapillary (0.3 to 0.9 nm) for water transport
- **Chemistry:** Oxygen-containing functional groups on the edges
- **Compatibility:** Excellent interaction with nanocellulose through hydrogen bonds (FT-IR). (***Beeran et al. 2016)***

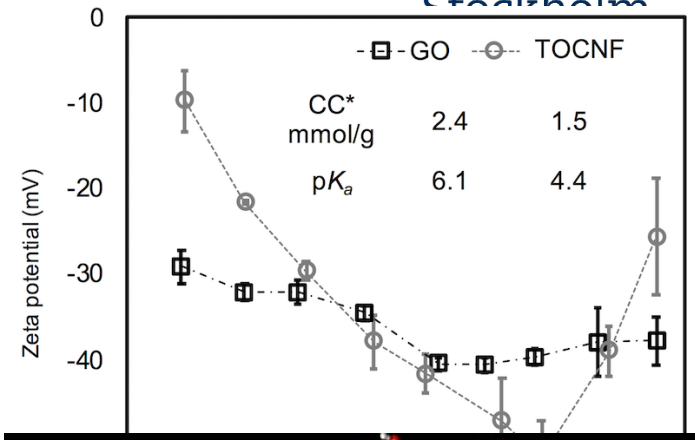


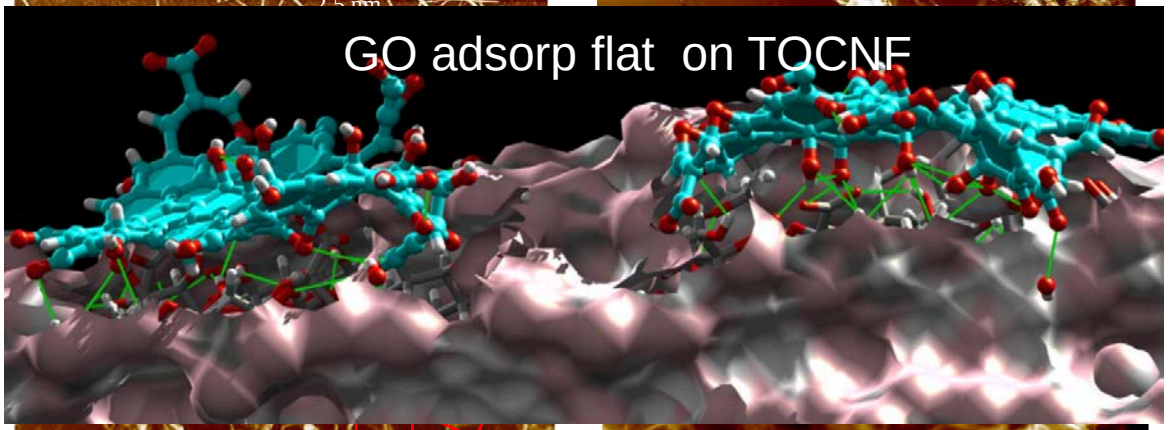


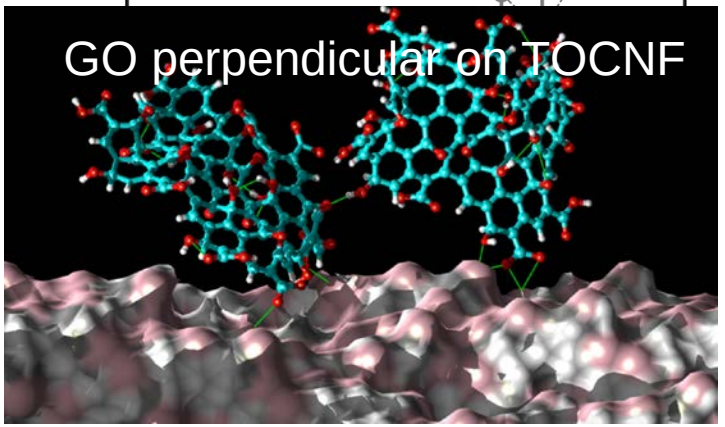
TOCNF-GO: Self-Assembly

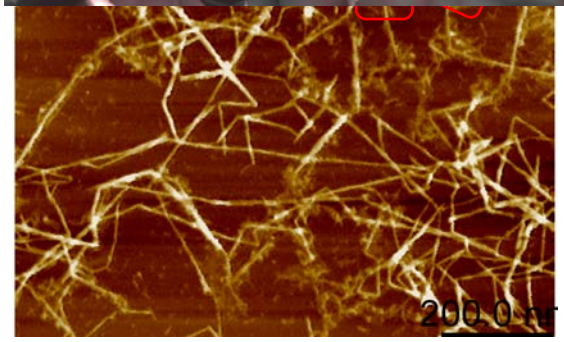


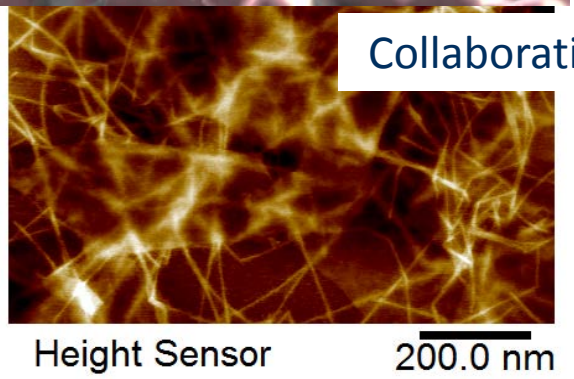












Collaboration with Susanna Monti, CNR, Italy

GO sheets on TOCNF

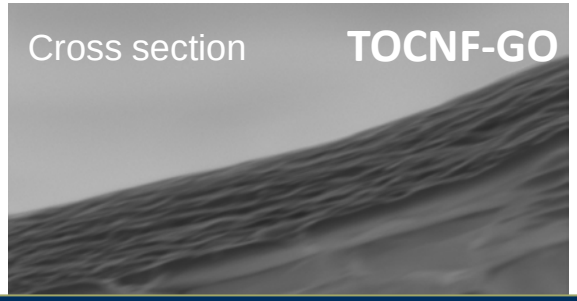
C. Zhu et al. ACS Applied Materials & Interfaces., 2017
C. Zhu et al. ACS Nano, 2018,,

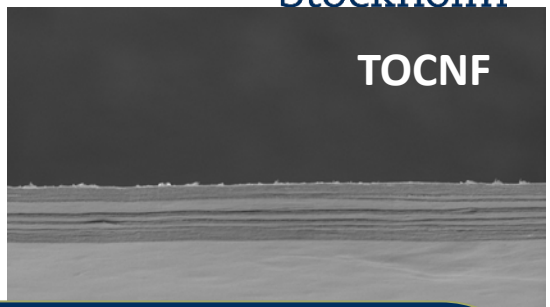
TOCNF-GO Membrane processing

Stockholm

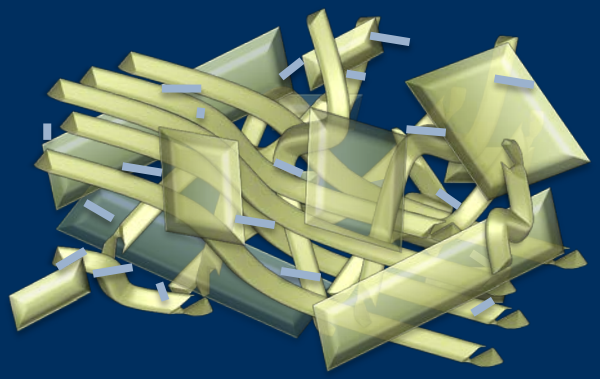


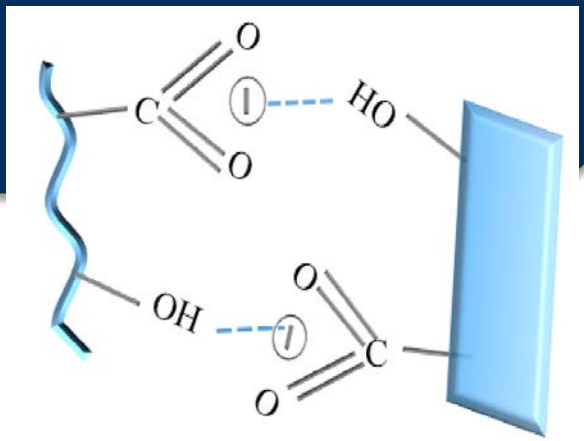
GO: TOCNF 1: 100

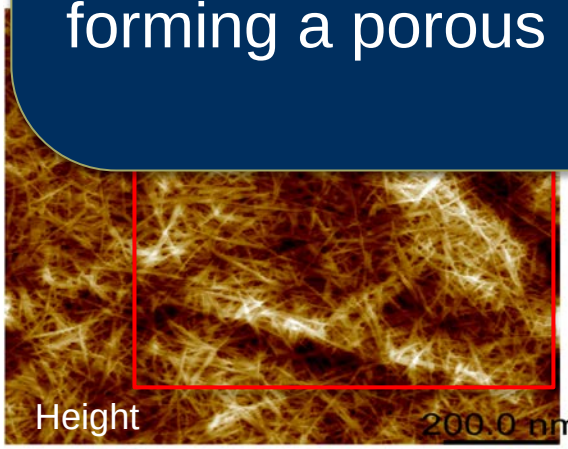




TOCNF-GO self-assembly driven by synergistic hydrogen bondings, as well as physical interactions where nanocellulose and GO wrap around, or cover each other, forming a porous hybrid system.







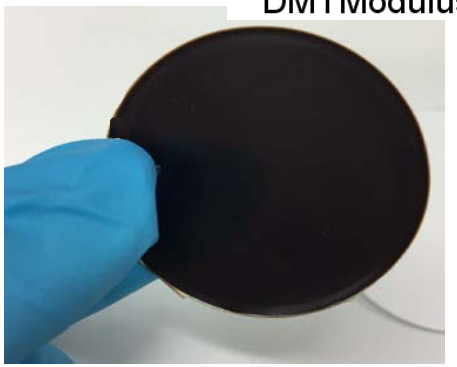
C. Zhu et al. ACS Nano, 2018

Mechanical Performance

Stockholm University

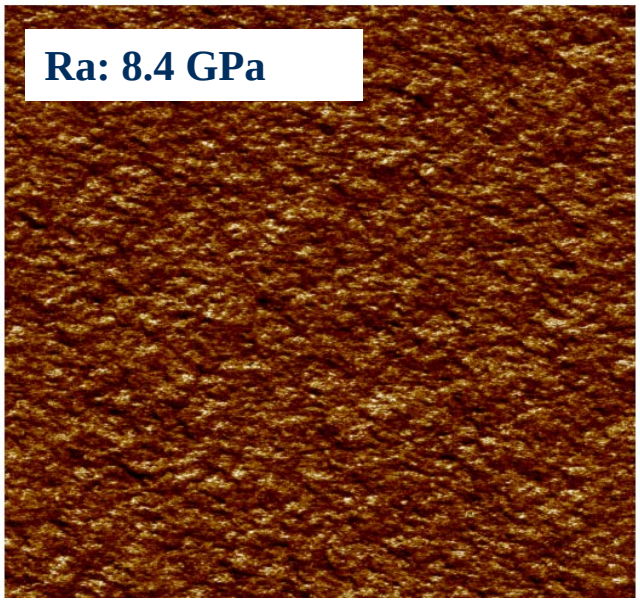


Vacuum Filtration

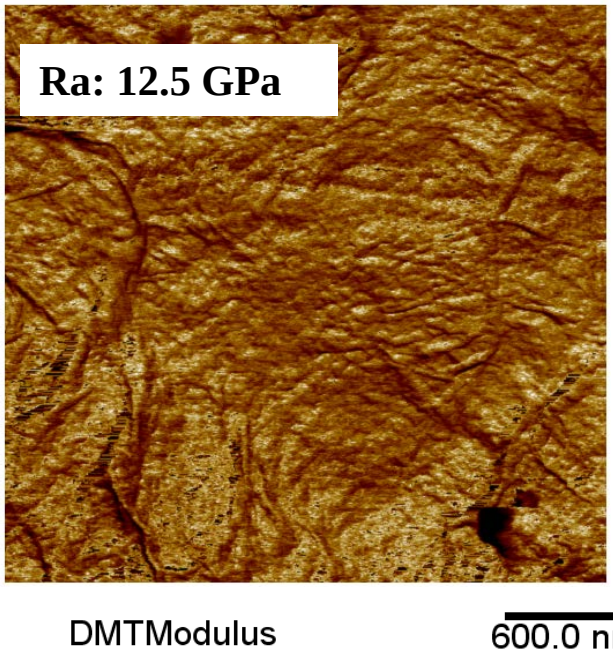


TOCNF+GO

TOCNF



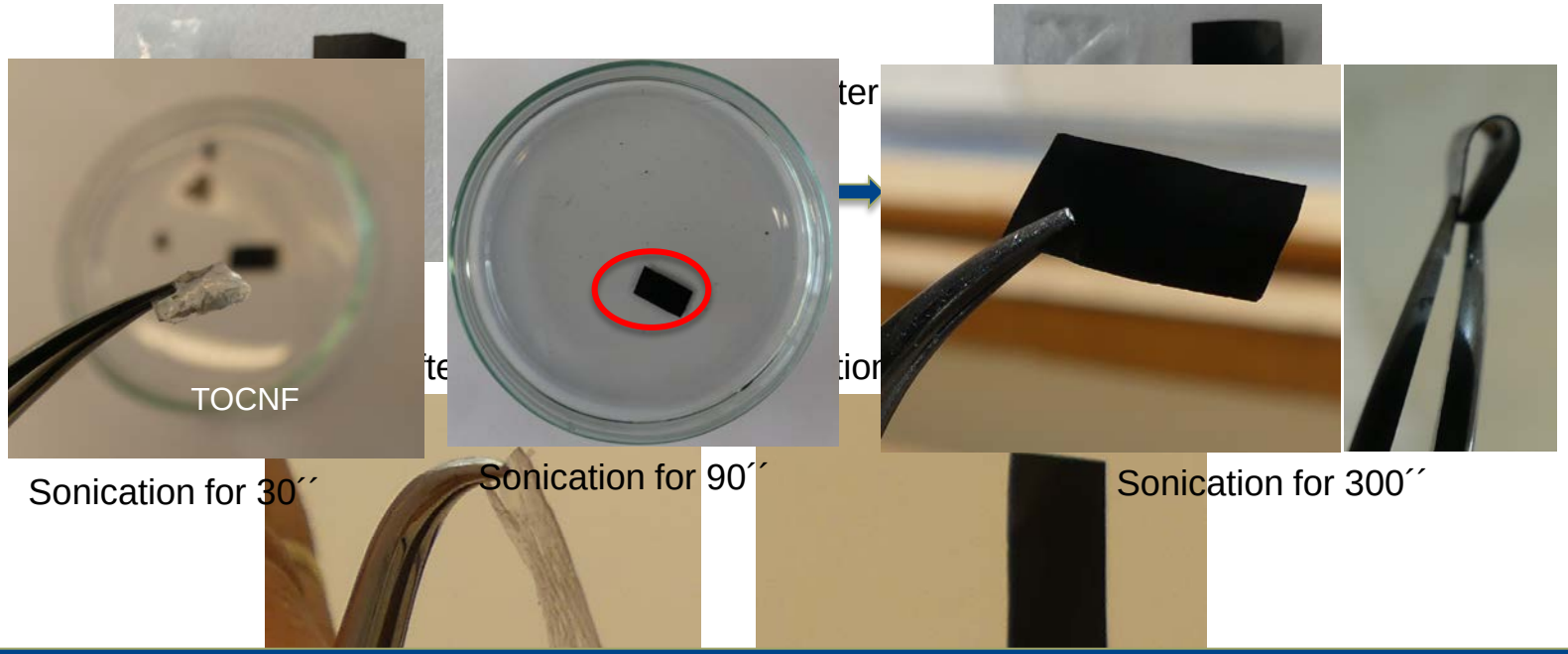
TOCNF+GO



Enhanced Modulus with GO

C. Zhu et al. ACS Applied Materials & Interfaces., 2017

Hydrolytic Stability and Recyclability



Hybrids show promising mechanical performance, recyclability and hydrolytic stability.

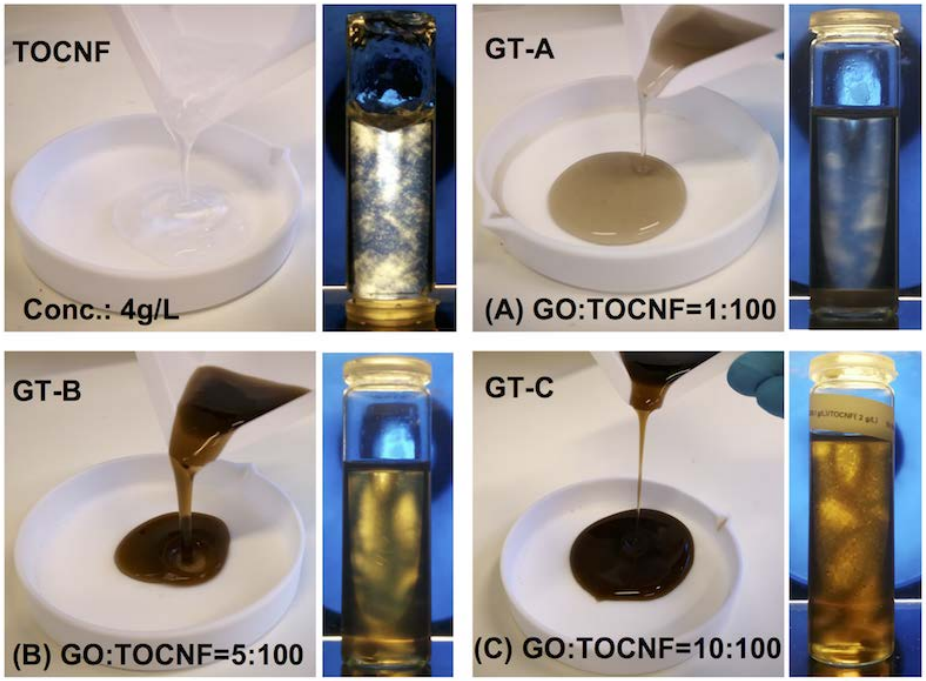
C. Zhu et al. ACS Applied Materials & Interfaces., 2017

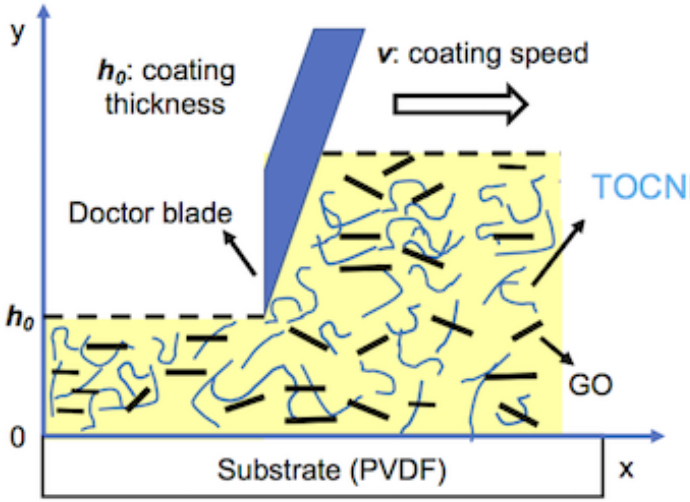
TOCNF- GO membrane coatings

Scalability and performance

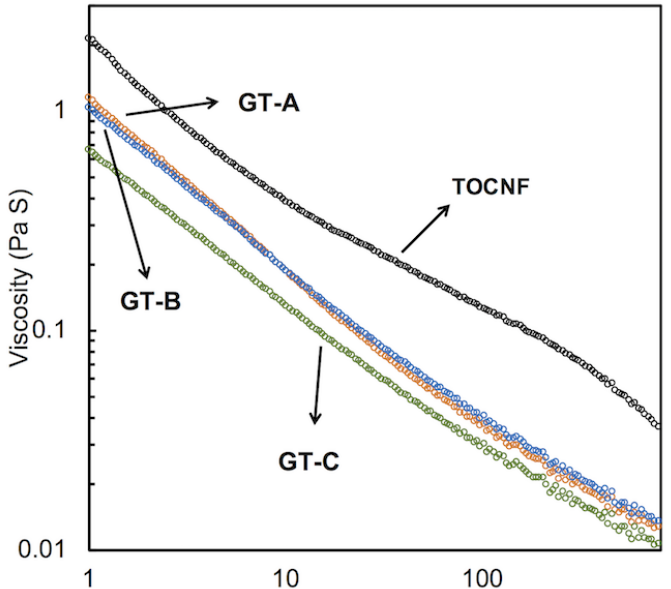
Stockholm University

GO -TOCNF coating





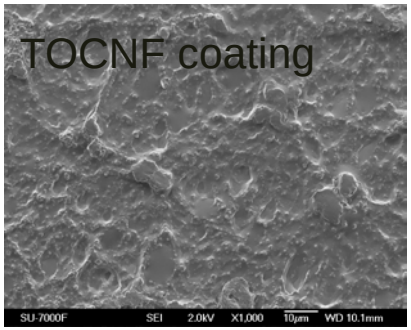
Substrate	Process parameters	
	h_0 (µm)	v_0 (cm/s)
PVDF (0.45 µm)	50	0.5

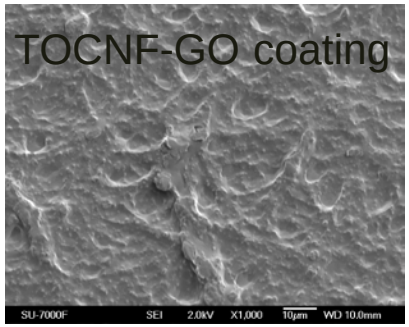


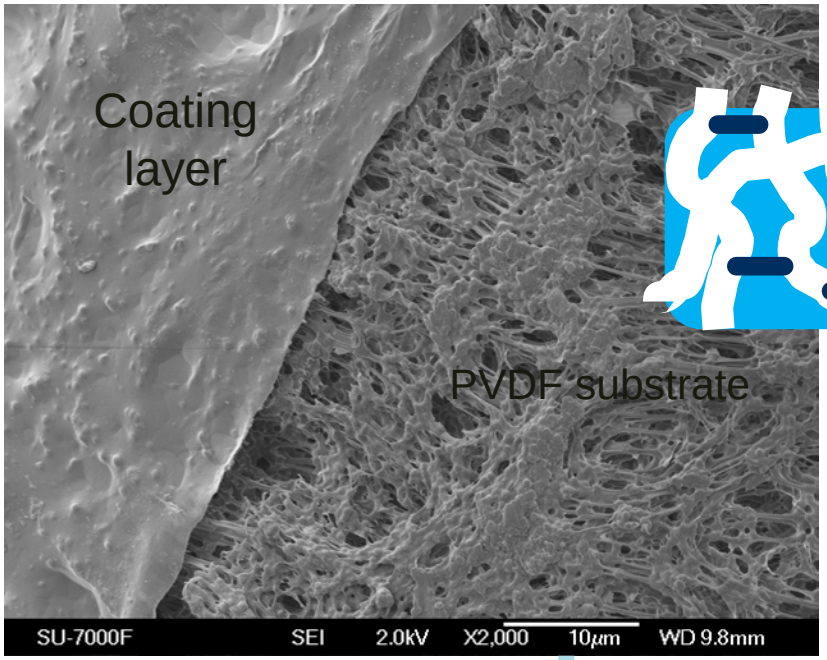
TOCNF- GO coated membranes

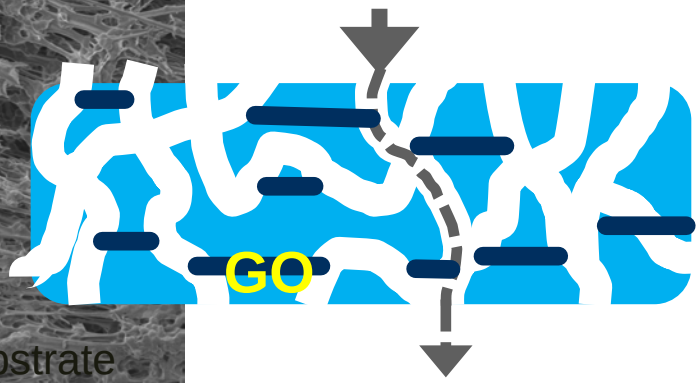
Morphology

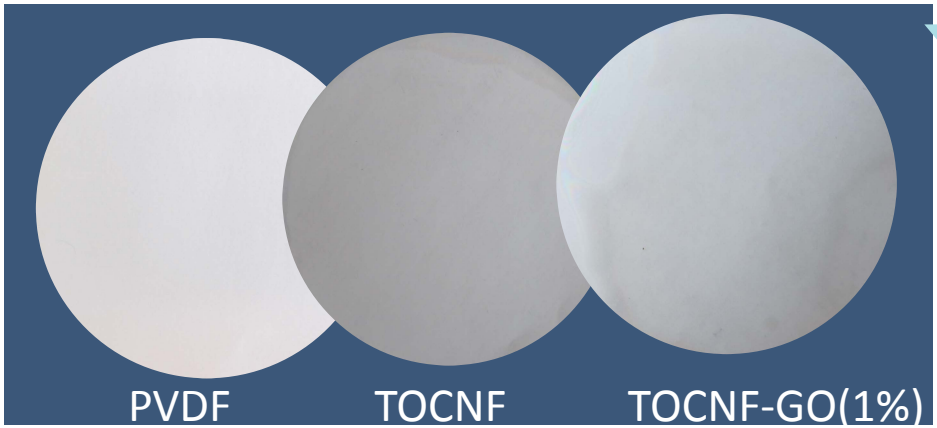
Stockholm University









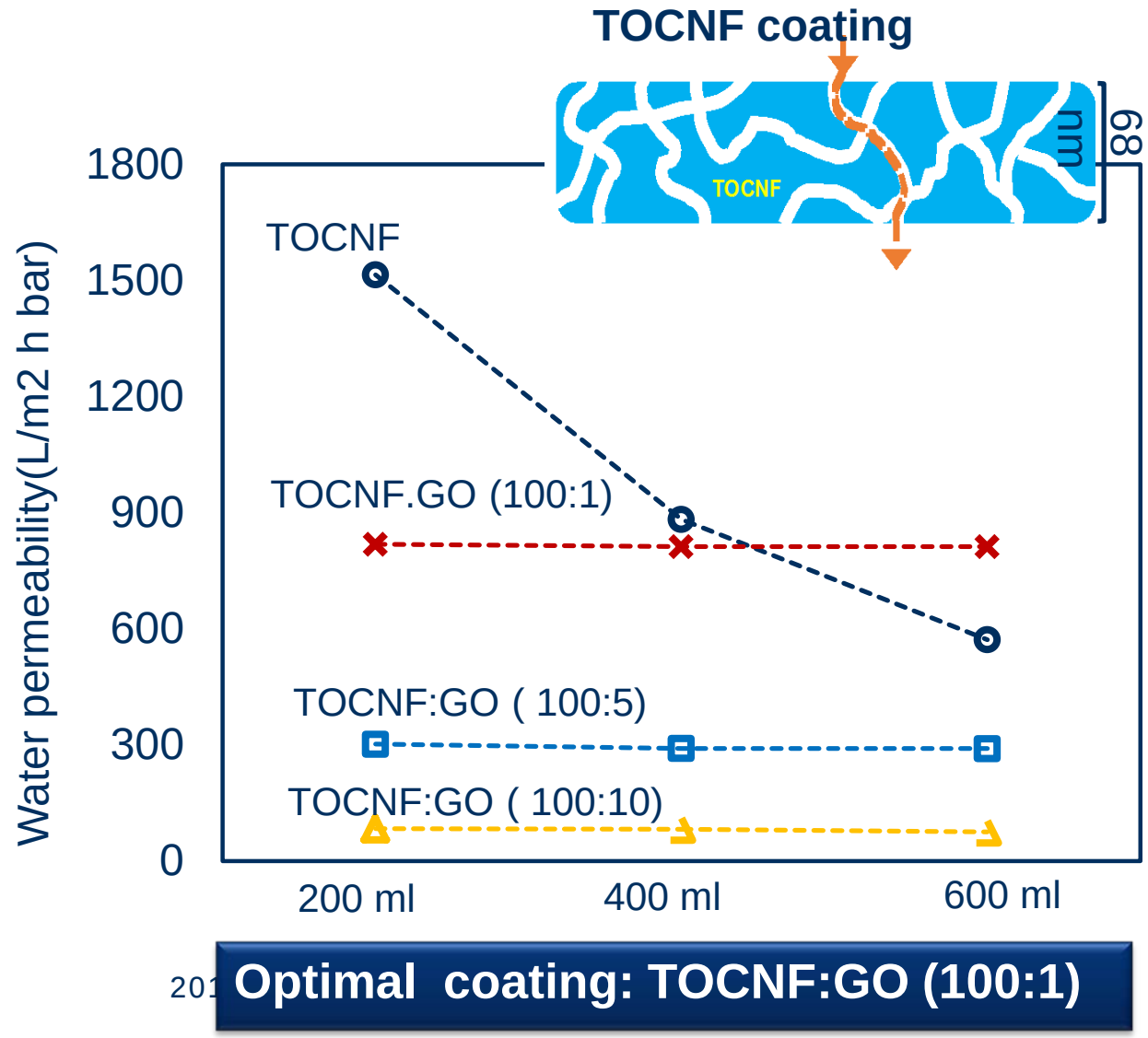


Dried coating layer		Substrate
Thickness (nm)	Grammage (g/m^2)	
68	0.1	PVDF (0.45 μm)

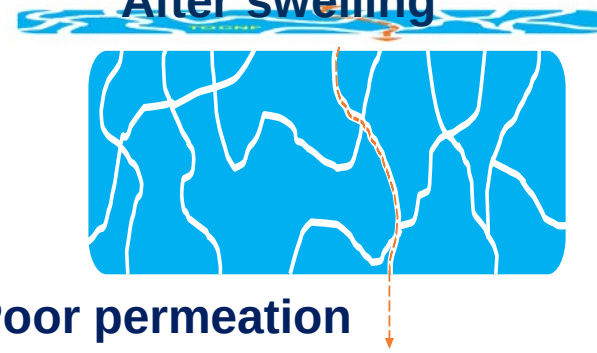
TOCNF- GO coated membranes

Permeability

Stockholm University



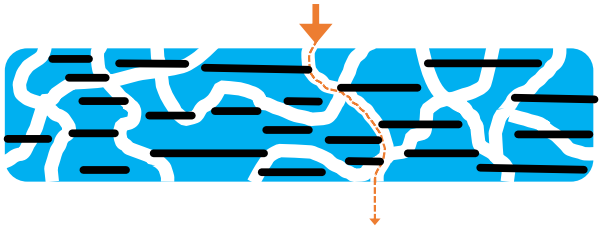
Optimal coating: TOCNF:GO (100:1)



Poor permeation stability due to swelling



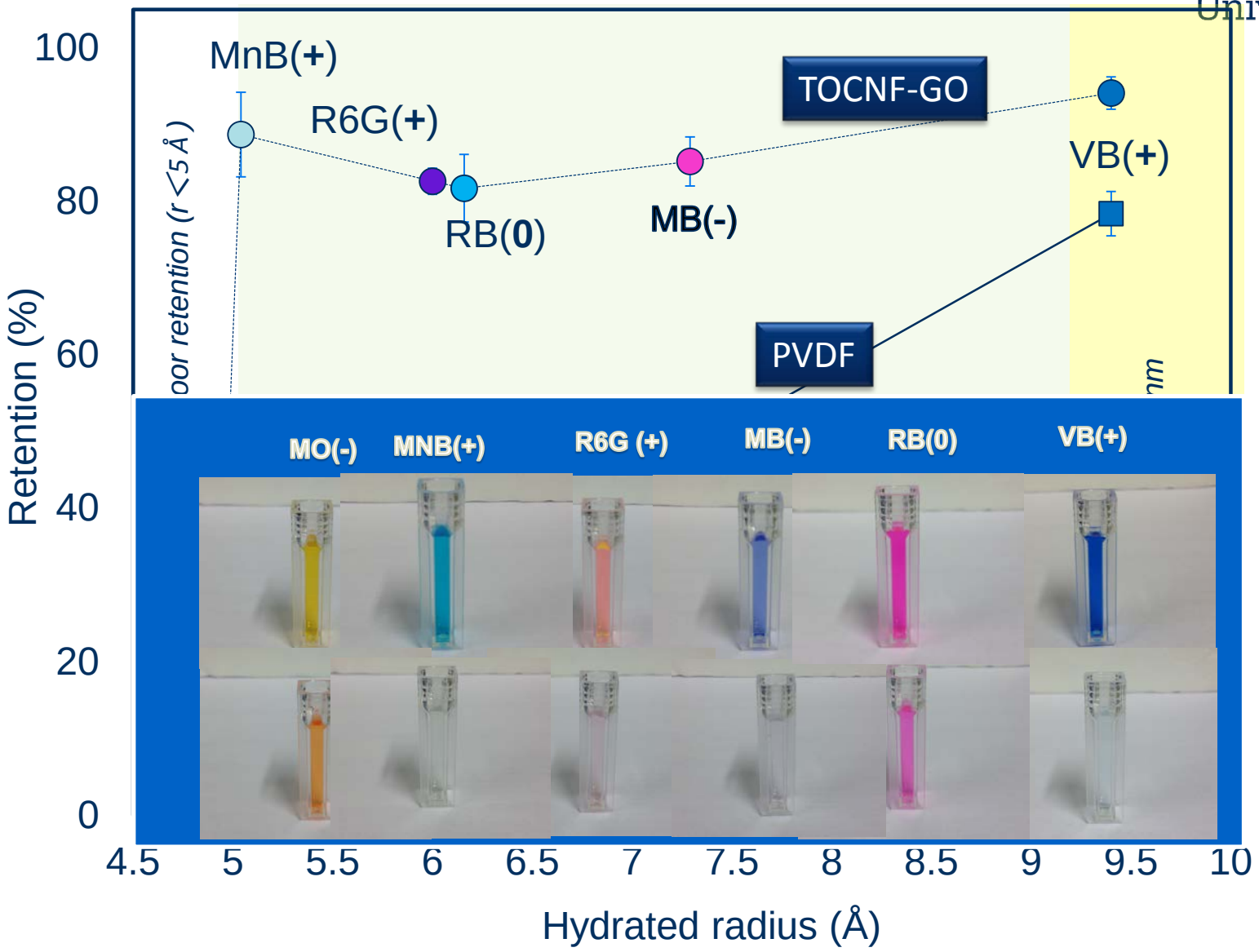
Good stability with high permeation



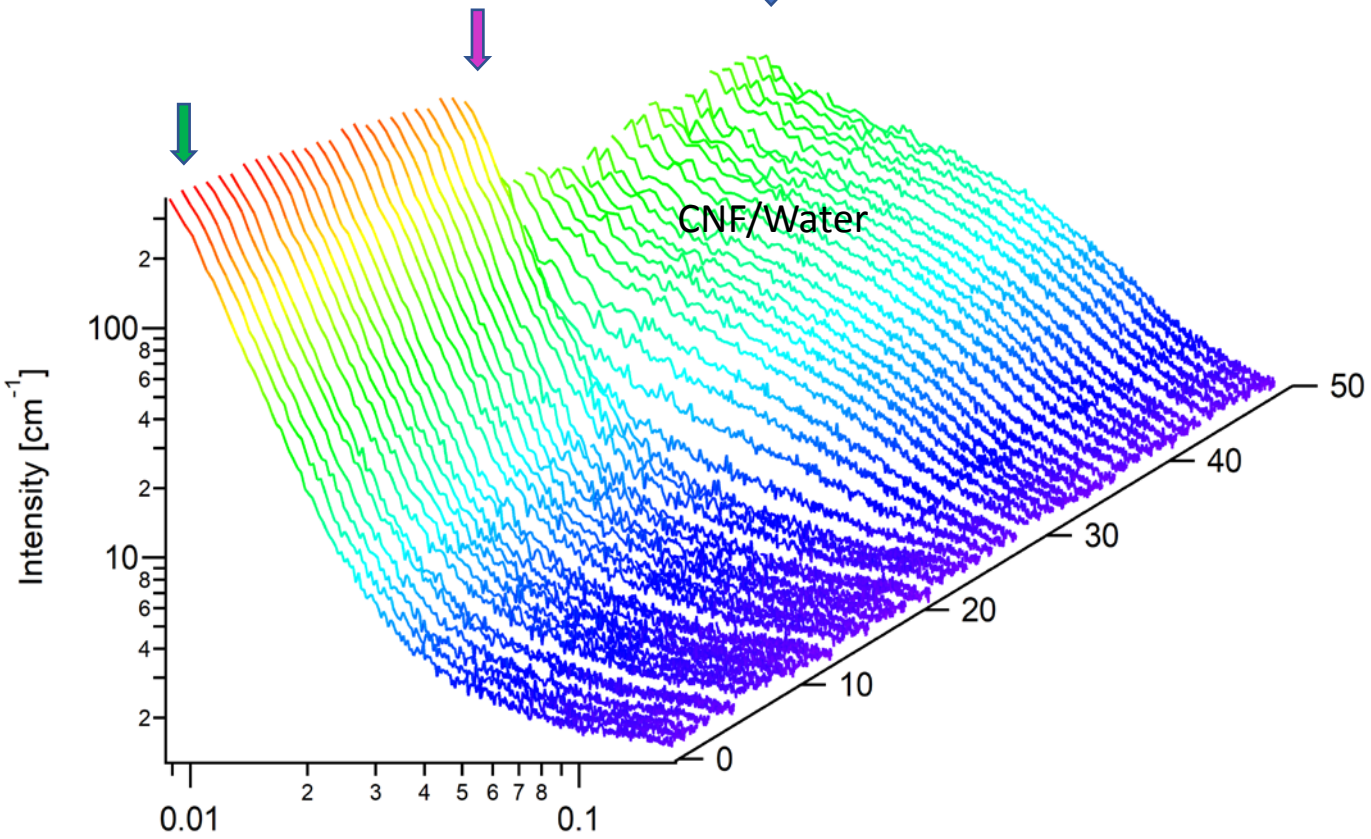
Good stability with low permeation

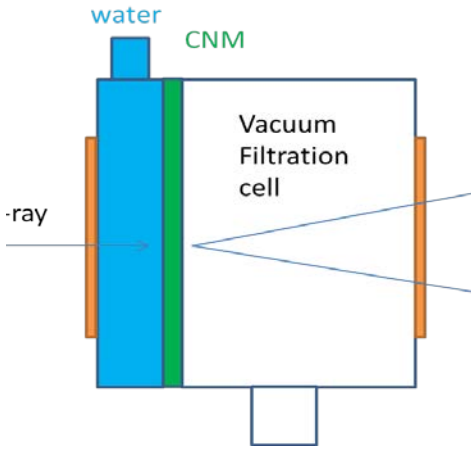
TOCNF- GO coated membranes

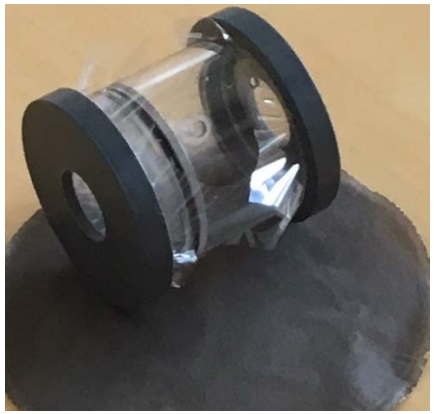
Dye removal



In situ small angle X-ray scattering (@ DESY, Hamburg)







$$I(q) = \frac{A}{(1 + (q \cdot \Xi)^2)^2} + \frac{B}{(1 + (q \cdot \lambda)^2)^2} + I_{BG}$$

Multiscale Debye-Anderson-Brumberger (DAB) model

Collaboration with Shun Yu and German Salzar Alvarez, SU

Conclusions

- Nanocellulose hybrid membranes for water purification prepared via i) vacuum filtration ii) coating

- Cellulose nanofibers self assemble with GO forming a porous , hybrid structure
  - Modifies pore structure
  - Improves hydrolytic stability, recyclability and pollutant rejection compared to TOCNF membranes

- Synchrotron-based SAXS, AFM and molecular dynamic modelling provide new insight into these hybrid membranes

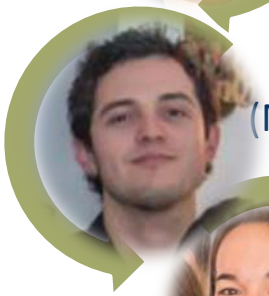
Acknowledgements

Funding agencies, People Involved,Collaborators…

Chuantao Zhu (AFM)



Luis Valencia (Membranes, insitu SAXS)



Blanca Jalvo (Membrane Fouling)



Peng Liu (Membarnes)



Andrea Aguilar (Coatings)



Sahar Sultan (3D printing)



Carlos Javier (Hybrids)



Dimitrios Georgove (Membranes)



Susanna Monti (Molecular dynamics simulations)



Vetenskapsrådet

WWSC

IMPACT FACTOR 3.504

Nanocellulose and Nanochitin: Characterization and Applicaitions

Guest Editor
Prof. Aji P. Mathew

Deadline
20 May 2019

Special Issue
Invitation to submit

Potential topics include, but are not limited to:

1. Nanocellulose/nanochitin isolation from biomass and residues
2. Processing strategies for materials from nanocellulose and nanochitin
3. Nanocellulose and nanochitin for functional applications
4. Novel characterization techniques to understand nanocellulose/ nanochitin based materials

Contact : aji.mathew@mmk.su.se
Ph: 0046-721474367